

# Acoustic differentiation of Australian populations of the Large Bentwing-bat *Miniopterus schreibersii* (Kuhl, 1817)

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## ABSTRACT

Variations in Large Bentwing-bat *Miniopterus schreibersii* echolocation call frequency throughout its range in Australia were investigated for patterns. Statistically significant differences were identified between the three main populations. Bats from Byaduk Caves and Warrnambool in Southwestern Victoria together with those from Naracoorte in South Australia form a southern phonotype (*M. s. bassanii*). Bats from East Gippsland in Victoria through to Torres Strait form the eastern phonotype (*M. s. oceanensis*). Bats from the Northern Territory form the third phonotype (*M. s. orianae*).

Key words: *Miniopterus*, echolocation, phonotypes, Anabat, Sampling, methodology

## INTRODUCTION

During 1995 I recorded calls of the bat known in Australia as the Large or Common Bent-wing Bat *Miniopterus schreibersii*. These call sequences from Southwestern Victoria and North Queensland differed in mean frequency ( $F_{\text{mean}}$ ) by about 3-5 kHz. They are separated by some 4000 km and one area is cool temperate the other wet tropical - some difference could be reasonably expected. I gathered more call sequences from throughout the species' range in Australia. I found that while call frequency of *M. schreibersii* was uniform along the entire length of the eastern Australian coastline from Cairns to Orbost, an abrupt change happened in central Victoria. Differences in call frequency were greater between bats from Eastern and Western Victoria than were any of the East Coast sub-populations between themselves.

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## METHODS

Call sequences analysed in this study were recorded with an ANABAT II electronic bat detector, and recorded either to cassette tape or directly digitised into a laptop computer (de Oliveira 1998). Where possible I recorded sequences, and usually directly into a laptop to maximise the quality of the recordings. I recorded bats around the openings of caves known to be occupied solely by *M. schreibersii*, or with known other taxa. Pulses selected for analysis were viewed with ANALOOK software (Chris Corben/Titley Electronics, Ballina, NSW), and chosen if they were near the end of a stabilised sequence of pulses, and were relatively long interrogative/orientation pulses. Any steep and short pulses generated in clutter or near other bats were rejected. Selected pulses could all be characterised as bicurvilinear (de Oliveira 1998). The unit of 'sequences' (table 1) is approximately equal to individual bats, but with the slight possibility that some individuals were sampled more than once at fly-outs.

Table 1. Summary call frequency data for *Miniopterus schreibersii* subspecies

Taxon	F <sub>mean</sub>			F <sub>k</sub>			n (pulses)	n (sequences)
	Mean (kHz)	SE	95% CI	Mean (kHz)	SE	95% CI		
<i>Miniopterus s. bassanii</i>	47.71	0.08	47.54 - 47.87	48.84	0.10	48.64 - 49.03	182	44
<i>Miniopterus s. oceanensis</i>	45.44	0.05	45.33 - 45.54	45.83	0.08	45.68 - 45.99	206	30
<i>Miniopterus s. orianae</i>	50.37	0.19	50.05 - 50.70	50.58	0.29	50.08 - 51.08	18	8

I also solicited recordings from other bat workers throughout Australia, and made selections from these based on recording quality and the same selection criteria outlined above. Sequences used in the analyses came from Byaduk Caves and Lake Gilear (southwestern Victoria); Naracoorte (eastern South Australia); Sydney and Wingham (eastern New South Wales); Brisbane and the Conondale Ranges (southeastern Queensland); Townsville (northeastern Queensland); Darwin (northwestern Northern Territory) (figure 1).

Parameters extracted from the *Miniopterus* sequences (mean frequency [ $F_{\text{mean}}$ ] and frequency of the knee [ $F_k$ ]) were subjected to exploratory statistical analysis, one-way ANOVA and a Tukey multiple-comparisons test (Fowler *et al.* 1998).

## RESULTS

One-way ANOVA of  $F_k$  confirmed a significant difference in call frequency between bats of the three sub-populations ( $F_{2,403} = 348.74$ ,  $P < 0.001$ ). The results for  $F_{\text{mean}}$  also show a significant difference ( $F_{2,403} = 377.46$ ,  $P < 0.001$ ).

A Tukey multiple comparisons test confirmed significant differences ( $Q = 4.498$ ,  $P < 0.05$ ) between the three main populations (*M. s. bassanii*, *M. s. oceanensis*, *M. s. orianae*) for both  $F_{\text{mean}}$  and  $F_k$  (table 1).

## DISCUSSION

*M. schreibersii* has three phenotypes in Australia. Bats from Byaduk Caves and Warrnambool in Southwestern Victoria together with those from Naracoorte in South Australia form a southern phenotype. Bats from East Gippsland in Victoria

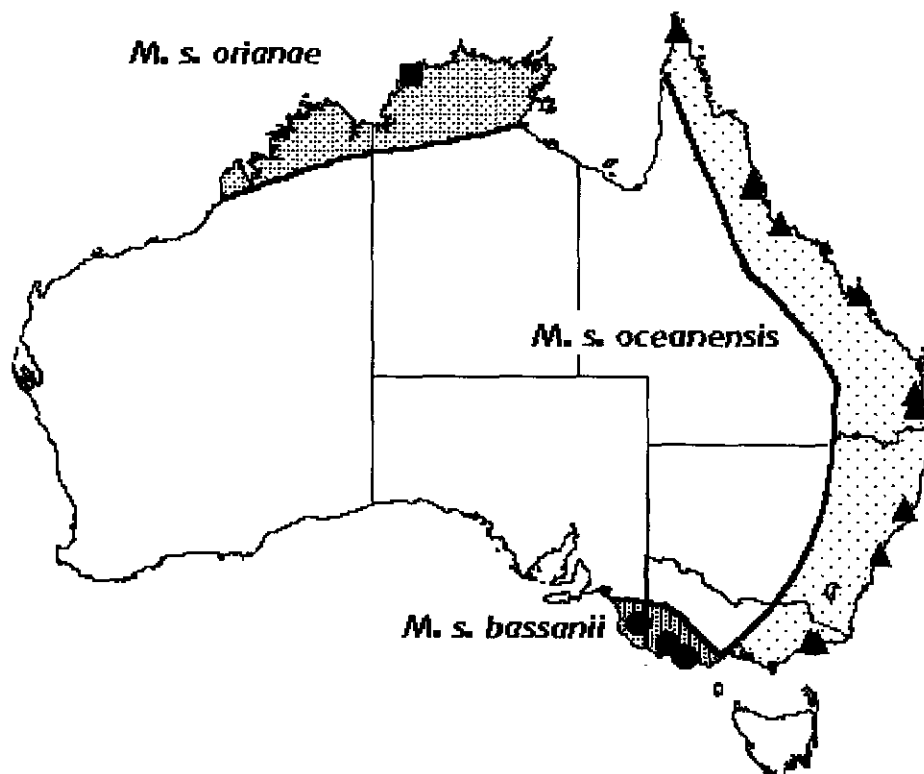


Figure 1: Map showing locations where *Miniopterus schreibersii* call sequences were collected for this study, and the distribution of the three subspecies.

through to Torres Strait form a second phonotype - the eastern. Bats from the Northern Territory form the third group - the northern phonotype. Cardinal & Christidis (2000) have subsequently proposed that populations equating to the three phonotypes represent genetically and morphologically distinct taxa - the Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*, the Northern Bentwing-bat *M. s. orianae* and the Southern Bentwing-bat *M. schreibersii bassanii*.

There is some overlap at the extremes between the phonotypes in the key identification parameters of  $F_{\text{mean}}$  and  $F_k$ , but this is only really an issue in Victoria where *M. s. bassanii* and *M. s. oceanensis* have a zone of overlap in central Victoria. The range of *M. s. orianae* does not overlap with any other known Australian *Miniopterus*. As shown in table 1, the 95% confidence intervals for each subspecies show a clear separation on both  $F_{\text{mean}}$  and  $F_k$  for the three forms. Banding has in the past shown movement of individual bats between the southern and eastern populations, but the exact extent of this movement is still little understood (Dwyer 1966). It has been suggested that it is rare for bats to move outside the territories centred on discrete maternity-cave based loci (Churchill 1998), but this can only be presumed to be what the majority of bats do. Cardinal & Christidis (2000) found a significant difference between *M. s. bassanii* and *M. s. oceanensis* using microsatellite markers in mitochondrial DNA, suggesting effective and ongoing reproductive isolation over a long period.

Another major implication from this work is that the calls of one taxon, *M. s. oceanensis*, are remarkably consistent over a wide latitudinal and environmental range. Though there has been much discussion of regional call variations and dialects within wide-ranging species, the evidence from rigorous analyses seems to be showing that in species where the taxonomic boundaries are well resolved, calls are consistent throughout the geographic range. Other examples of this include the Hoary Bat *Lasiurus cinereus* throughout continental North America (Chris Corben pers. comm., 17/11/1999), and Gould's Wattled Bat *Chalinolobus gouldii* throughout Australia (Linda Reinhold pers. comm., 14/1/2000).

Acoustic studies are useful for pinpointing taxonomic problems, and in targeting research on their resolution. Where significant differences in call parameters such as frequency are found, care must be taken to establish that the calls used in the analysis have been collected from bats under

reasonably uniform conditions, and from bats engaged in the same kinds of activities. Some observed differences arise from calls collected in quite different acoustic environments (open, cluttered, enclosed, etc.), or engaged in quite different activities (foraging, commuting, obstacle avoidance, etc.). Even different foraging strategies employed by a single species (eg. aerial pursuit, sally-strike, etc.) would likely give rise to slightly different acoustic signatures. Taking all this into consideration, significant differences found in standardised recordings may well arise from the presence of cryptic species or species which are poorly defined in a taxonomic sense.

In seeking to standardise the collection of calls and subsequent sub-sampling of call pulses, I developed a simple methodology. Though perhaps obvious, I think there a number of basic but very important issues to be considered in this process.

- i. It is important to standardise collecting conditions in the field as far as is practicable. Roost-exit recordings should be compared with similar recordings such as from other roost-exits or some hand-releases. Watching the bats to see what they are doing will also aid in selecting appropriate sequences for comparison.
- ii. When selecting individual pulses from a call I looked for stabilised pulse trains, usually in the second half of a recording. This means that the bats are generally heading away from the detector and there may be a bias towards negatively Doppler shifted frequencies (Chris Corben pers. comm., 17/11/1999). Consider this effect if comparing with pulses from the first half of a recording (bias towards positively Doppler shifted frequencies), or mixing the two. There is little point including the highly variable linear pulses that *Miniopterus* makes as it negotiates clutter around a roost exit with the more stable bicurvilinear pulses that it makes in level flight. The two call types have very different characteristics and functions, and will lead to messy, confusing and highly variable results if combined for analysis.
- iii. Provided that due attention is paid to the above points, and all other things being held equal, some meaning can be attached to the subsequent results of statistical analysis.

Further, the relatively simple zero-crossing technology represented by the ANABAT detector has proved well suited to the gathering of large amounts of data for meaningful analysis.

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